related lines of work without, however, interfering in any way with the integrity of the organization of the several Divisions. He reports the affiliation in this manner of four important Divisions closely allied by the nature of their work under the name of the Office of Plant Industry.

LABORATORY BUILDINGS.

An urgent recommendation is made for the erection of new, fireproof laboratory buildings, which, it is estimated, will cost about $200,000.

DIFFICULTY OF RETAINING EXPERTS.

One of the problems constantly recurring to the head of the Department is the difficulty of retaining in the service some of the most capable and efficient of its workers. During the past year three valuable workers were lost to the Department, and other losses are threatened, owing to the tempting offers made to Department experts from other sources. The Secretary recommends that Congress place it in his power to exercise a wider discretion in the matter of salaries to responsible officers.

ARLINGTON FARM.

Under the authority of Congress work has been begun on the Arlington estate with a view to establishing an experimental farm on the land set apart for the use of the Department.

DOMESTIC SILK CULTURE.

In 1899 the United States paid over $32,000,000 for imported raw silk, and in 1900 over $45,000,000. The Secretary believes that a large amount of cheap and now unemployed labor among the colored youth in the Southern States could be made available for domestic silk culture; and he desires an appropriation of $10,000 to set on foot research regarding the production of silk, to the end that the money now paid to foreign labor be distributed at home.

*STANDARD METHODS OF WATER ANALYSIS.**

As its first report of progress, the Committee on Standard Methods of Water Analysis presents the results of a careful inquiry into the present status of this general subject. This step was deemed necessary in order to bring to the Committee needed information for its guidance in its future plans of action.

About 125 copies of a circular letter, with an accompanying list of questions, were sent to leading workers. The number of detailed replies was fewer than should have been the case. Nevertheless, these replies, with the knowledge which the members of this Committee have as to the methods used in the more prominent laboratories, enable us to present a substantially correct *résumé* of existing conditions, as given in the following pages.

Collection of Samples.—Upon the subject of collection of samples the replies to the question sent to various workers were practically unanimous, and may be summarized as follows:

Bottles for chemical samples should have a capacity of one gallon, should be made of clear white glass in order to facilitate inspection, and should have glass stoppers. They should be washed each time before use with sulphuric acid and potassium bichromate, or with alkaline permanganate, followed by sulphuric acid; they should then be thoroughly rinsed and drained. For shipment the stoppers and necks of the bottles should be protected with cloth tied over them. They should be packed in cases with separate compartments for each bottle, and lined with indented fiber paper, felt or some similar substance, or provided with

* Report presented at the Indianapolis meeting of the American Public Health Association by a committee comprising Mr. George W. Fuller, chairman; Mr. George C. Whipple, secretary; Mr. Harry W. Clark, Dr. Adolph Gehrmann, Dr. Wyatt Johnston, Dr. E. O. Jordan and Dr. H. L. Russell.

corner spring strips to prevent breaking. The packing boxes should be covered and provided with suitable fastenings.

Bottles for microscopical samples should have a capacity of at least one quart, and should be of clear white glass, but they need not have glass stoppers. Bottles for bacterial samples should have a capacity of at least four ounces and should have wide mouths and glass stoppers. Before use they should be washed as described above, and then sterilized with dry heat for one hour at 160 degrees C., or in an autoclav at 115 degrees C. for fifteen minutes. For transportation they should be wrapped in sterilized cloth, or the neck should be covered with tinfoil and the bottles put in a tin box. When bacterial samples must of necessity stand for more than twelve hours before plating, it is preferable to use larger bottles than four ounces. The gallon bottle used for the chemical sample may be sterilized and used for the entire analysis. When samples are not plated at the time of collection, they should be kept on ice at not less than 10 degrees C. Portable ice-boxes with separate compartments for the ice and bottles may be sent by express with satisfactory results.

The allowable time that may elapse between the collection of a sample and the beginning of its analysis cannot be stated definitely, as it depends upon the character of the sample and other conditions, but the following limits are generally safe:

Chemical analysis.—For fairly pure surface waters, 24 to 48 hours; and for normal ground water, 48 to 72 hours. Polluted water requires analysis within twelve hours.

Microscopical examination.—For fairly pure waters, 24 hours. If fragile organisms, such as Uroglena, Synura, etc., are present, immediate examination may be necessary.

Bacteriological examination.—Immediate plating is always best, but seldom practicable. With fairly pure waters packed in ice, plating within 12 hours after collection will not introduce errors sufficient to vitiate the results.

Physical Examination.—The physical examination includes observations of the temperature, general appearance, color, turbidity and the odor in hot and cold samples.

The temperature should be taken at the time of collection, and expressed, preferably Centigrade degrees, to the nearest 0.5 degree. For obtaining temperature of water at various depths the thermophone gives the most accurate results.

The general appearance of the water should be determined by inspection in strong light after standing several hours. Substances remaining in suspension are then classed as 'turbidity on standing,' and substances settling to the bottom, as 'sediment.' The terms, none, very slight, slight, distinct, decided, etc., may be used for general work as described in the reports of the Massachusetts State Board of Health Where methods are used for expressing the turbidity and suspended matters numerically, as is necessary with sewage and some waters in some lines of work, the description of appearance may be omitted.

At the present time there is no uniformity in the methods of measuring turbidity or suspended matter. The wire method, the disk method, the diaphanometer method, the gravimetric method, and the use of standards of comparison all appear to have their field of usefulness. It is desirable that some system should be adopted for making the results by the various methods comparable, at least for those lines of work of the same general nature. In the absence of the necessary experimental data, your Committee is unable to make a definite recommendation at present, although studies now in hand will probably make this possible another year.

For measuring the amount of dissolved coloring matter in waters, the platinum-cobalt scale appears to be very generally used, although the Nessler and natural water standards and other methods are being used in important work. While the platinum standard does not appear to be wholly satisfactory, especially for very dark-colored waters, it appears to be generally suitable for ordinary use and serves well as a basis of comparison for all results. Your committee recommends that whenever any other method is used for color measurement, the relation of this method to the platinum standard shall be indicated. In the case of waters which are appreciably turbid, the suspended matters should be removed before determining the color which relates strictly to soluble matters.

The odor should be observed in both hot and cold samples, and the results recorded in terms expressing quality and intensity, substantially as described in the paper on this subject presented to this Section last year. (*Transactions* A. P. H. A., 1899, p. 587.)

Microscopical Examination.—The modified Sedgwick-Rafter method appears to give general satisfaction. The majority of analysts express the results in 'Number of Organisms per Cubic Centimeter,' but those who have had the largest experience with the method prefer to express the results in 'Number of Standard Units per Cubic Centimeter.' Inasmuch as the latter method takes into account the size of the various organisms, and may also be used for the amorphous matter, your Committee favors the general adoption of the standard unit method.

Chemical Analysis.—So far as your Committee has been able to learn, the chemical methods used for an ordinary sanitary analysis of a water do not vary very materially in those laboratories where most of this work is now being done. As a rule, the differences which are found appear to be justified by the differences in the nature of the waters and the objects of the work. It appears, however, from general observation, that there is room for improvement in a number of laboratories in which water analyses are made in small numbers and at irregular intervals. The determinations which from general opinion are considered necessary for a satisfactory sanitary analysis of an ordinary water are as follows: residue on evaporation, total and dissolved, with the loss on ignition in some instances; nitrogen as albuminoid and free ammonia, nitrites and nitrates; oxygen consumed; chlorine, and hardness. The general consensus of opinion regarding these determinations is quite harmonious on the whole, and the best current practice may be outlined in brief terms as given beyond.

Within the past few years water analysts have had occasion to study types of water about which very little was known a few years ago, and to assist in a variety of special problems relative to water pollution and various processes for the purification of both water and sewage. Such investigations have naturally resulted in an increase in our knowledge concerning a number of analytical matters, about which there was comparatively little known, in practical terms, in this country, a dozen years ago. Among the analytical methods relative to these studies, of a more or less special nature, may be mentioned those for alkalinity, iron, sulphuric acid, carbonic acid and dissolved oxygen. While the methods for these and other determinations have been carefully worked out with reference to certain conditions and waters of certain types, it is felt by the Committee that there are a number of details which can to advantage be left in abeyance until another year. The general trend relative to these so-called special methods is outlined briefly beyond.

With regard to the limits of accuracy of the several methods under various conditions, the determinations which can be best applied to various problems, the expression of the results of analysis and the interpretation of their results are all matters upon which the Committee has nothing to say until a further expression of experience and views is received from members of the Section.

Residue on Evaporation.—The amount of water used should be preferably such that the residue will weigh from three to twelve milligrams, although with sewages a greater weight is allowable. Experience alone can indicate the volume of water to be taken. Relative to dissolved residue, the suspended matter can be satisfactorily removed from surface waters of the glacial drift formation and from sewages by filtration through filter paper. The sub-microscopic clay particles of the Southern and Western waters can be best removed by a small Pasteur filter. This is not wholly satisfactory, as in some instances dissolved matters are absorbed by the filter, and in other cases they are removed from those stored in the filter. On an average it yields fair results, and no improvement can be suggested at this time.

With regard to the use of sodium carbonate, practice varies, but it would seem to be wise to add it (with a deduction from total weight) in those waters and sewages in which it is of value to obtain the loss on ignition. Evaporation is almost invariably obtained in a steam bath at a temperature of nearly 100 degrees C. The loss on ignition, it is believed, can be secured best with the use of a radiator in accordance with Drown's suggestions, although this device is not in general use. In fact, there is a growing tendency among workers to omit this determination, except for sewages and those waters relatively high in organic matter.

Chlorine.—This is determined always by titration with a standard solution of silver nitrate, using potassium chromate as an indicator. Colored surface waters first require decolorization by the addition of aluminum hydrate. The volume of water to be taken depends, of course, upon the amount of chlorides present. With unpolluted surface waters in the East, from 200 to 250 cubic centimeters should be concentrated by evaporation. In the case of sewages and highly polluted water containing much organic matter, satisfactory results can be obtained by evaporation to dryness, ignition of the residue and subsequent solution of the chlorides with hot, distilled water. The titration should be regularly made with volumes substantially the same as employed in the standardization of solutions.

Nitrogen as Free and Albuminoid Ammonia.—The volume of ordinary water taken for distillation is 500 cubic centimeters, and with very highly polluted waters or sewages smaller quantities are taken and diluted to the above amount with ammonia-free distilled water. Where many sewages are analyzed the volume taken may be 10 cubic centimeters or less, in accordance with Hazen's method. As a general rule, it seems advisable to add a few drops of a saturated solution of sodium carbonate before distillation. It is advisable to collect the distillate in the Nessler tubes in which this color is to be read. The rate of distillation should be 50 cubic centimeters in 5 or 6 minutes. It is an almost universal custom to collect three tubes of 50 cubic centimeters each, for the free ammonia, and five tubes for the albuminoid ammonia. In regard to the preparation of alkaline permanganate and Nessler solutions, the directions in any good text-book may be followed, and the individuality of various workers in these particulars is apparently not a factor affecting unfavorably the accuracy of results. Both the distillates and

the standard ammonia solutions should be of the same temperature before the addition of the Nessler solution.

Nitrogen as Nitrites.—No method superior to the Warrington modification of the Gness method is now known (see page 527, Special Report, Mass. State Board of Health, 1890, Part II.).

Nitrogen as Nitrates.—The determination of nitrogen as nitrates is made almost exclusively by two methods, the phenol-sulphonic acid method of Grandval and Lajoux, and the aluminum reduction method. With waters comparatively high in nitrates, and if a good brand of nitrogen-free caustic soda can be obtained, the aluminum method is more easily worked, and gives better average results. With waters low in nitrates and low in chlorine, the phenol-sulphonic acid method gives as good or better results than the reduction method. It is intended to consider the comparative merits of the two methods in detail in the later report.

Oxygen Consumed.—Practice varies widely both here and abroad with reference to the method for this determination; and many analysts omit it from the analyses of certain types of water. For sewages and those waters which are high in organic matter it undoubtedly yields valuable information. It would appear advisable to adopt a uniform procedure intermediate between the wide extremes now practiced. Such would be afforded by the addition of the reagents to the water when cold, and boiling for five minutes.

Hardness.—For ordinary sanitary work the soap method is commonly used, and for the soft Eastern waters it appears to give reasonably satisfactory results. For the hard waters of the West, Hehner's acid method is preferred. There are some details connected with the determination of the permanent hardness by the Hehner method which require further study.

Alkalinity.—This determination can be satisfactorily made by Hehner's method. Methyl orange is used by some workers as an indicator, while recent comparative studies give the preference to lacmoid or erythrosine. The latter indicators have the advantage, in connection with the use of coagulants, of affording the most reliable test for the presence of undecomposed alum in water.

Relative to the latter point, the logwood test is considered satisfactory by some workers, while by others it seems to be more of a qualitative test than a quantitative one. The differences in opinion are very likely due to unappreciated differences in manipulation which require further study.

Iron.—There are evidently several methods of an allied nature which can be used successfully for this determination, provided they are carefully applied. In another report the Committee can probably give a graded set of procedures, applicable to various conditions of practice. Thompson's method as described in Sutton's 'Volumetric Analysis' appears to be most generally used.

Sulphuric Acid.—Wildenstein's method as described by Ohlmuller has proved very satisfactory for certain lines of work, and preferable to the gravimetric method. Whether or not this is true under a wide range of conditions remains to be seen.

Carbonic Acid.—For Eastern waters Pettenkofer's method as described by Sutton is considered to be generally satisfactory; while for the Western waters Trillich's modification of this method, as described by Ohlmuller, is preferred by some workers. This method gives both the free and half-combined carbonic acid. There is a growing tendency among chemists to attach the more importance to the free carbonic acid alone. This can be obtained differentially by the method by which the free carbonic acid is removed, by the passage of the water

through a tube containing small gravel stones, with a current of air drawn in the opposite direction. Further study of this entire subject will place it on a more substantial basis.

Dissolved Oxygen.—There appear to be several methods which can be used successfully for this determination. The method in most general use, however, is that of Winkler as described in the Special Report of the Massachusetts State Board of Health, 1890, Part I.

By way of general comment it may be added that recent developments in sewage purification have indicated the desirability of special attention to several matters. Among them is the advantage coming from a more general use of the determination of suspended matters in sewage, with the loss on ignition. Another point is the desirability of determining the organic nitrogen in unpurified sewage by the Kjeldahl method, in view of the varying percentage of this constituent which is afforded by the albuminoid ammonia. The so-called 'incubation test' to show the relation to putrefaction of sewage after purification seems to have much practical value, under certain conditions, although the details cannot be considered at this time.

Quantitative Bacterial Examinations.—With reference to this subject, there has recently been a marked improvement in the general results obtained in this country. It is true, however, that methods of different workers are still variable to a degree which seems unnecessary, and which is certainly not desirable, when we consider that the value of this class of data relates largely to purposes of comparison.

The culture medium now in general use is nutrient gelatine, prepared substantially as recommended by the Bacteriological Committee in their Report of 1897. Meat extract, however, is still used by a number of workers, in place of meat infusion. Data are lacking to justify this as a general procedure. For some special lines of work nutrient agar is used with apparent advantage. These conditions refer to analyses of decomposed or stale sewage, where the number of bacteria capable of rapid liquefaction of gelatine is very large; and also to certain lines of field work. Several investigators have tried media of modified composition, containing new ingredients in some instances, but the present evidence is altogether too inconsistent and indefinite to permit of any recommendations along this line.

Concerning the reaction of the nutrient gelatine, the optimum varies under different conditions. Speaking in general terms, the majority of waters now studied appear to require ordinarily about 1.0 per cent. acid. There are some waters for which this reaction is too acid, and the sewage of some manufacturing cities evidently requires an alkaline medium. For important continuous work the reaction to be used should be carefully worked out with reference to the local conditions.

The amount of agitation which the sample of water should receive before plating, in order to insure mixing and a separation to a reasonable degree of groups of bacteria, is afforded by 25 vigorous shakes of the partially filled sample bottle.

Most workers arrange, so far as practicable, to have not more than about 200 colonies on the ordinary plate, such as Petri dishes having a diameter of about 4 inches. For those waters in which such numbers of Bacteria are contained in small fractions of one cubic centimeter, it is the general practice to dilute them with sterilized water, rather than to use pipettes delivering small fractions of one cubic centimeter.

The amount of nutrient gelatine used for each plate ranges at different laboratories from 5 to 10 cubic centimeters. Most workers use more than 7, while in some of

the largest laboratories the quantity is 5 cubic centimeters. For results to be obtained after four or more days of cultivation, the larger quantity is doubtless preferable. For results to be obtained after two days' growth, 5 cubic centimeters are found to be more satisfactory.

Practice varies with reference to mixing the water and the gelatine in the tube or on the dish, in those cases where Petri dishes are used. There is no evidence to indicate that this is a point of much practical significance, affecting results beyond the ordinary limits of accuracy.

With regard to standard conditions of cultivation, the best available evidence shows that it should take place in the dark and in an atmosphere in which moisture and oxygen are always present. Petri dishes sometimes fit too tightly to give satisfactory results, and special attention is necessary to these particulars. The temperature of cultivation should be uniformly 20 degrees C., and it is gratifying to note that in many laboratories this standard has been adopted, notwithstanding the care and expense which it sometimes involves.

The period of cultivation still varies considerably in the different laboratories. There is a well-defined movement, however, toward shorter periods in order to secure greater practical value for the data. These practical advantages outweigh the smaller numbers obtained from a shorter period, especially as all results have only a relative and not an absolute value. In Germany 48 hours is the standard period of cultivation, and daily results have been obtained on this basis from each of 26 water purification plants in operation in that country. There seems to be no good reason why the bacterial results to be obtained from the various water purification plants now in operation and about to be built in this country should not be comparable with those obtained abroad. This is especially true in view of the growing appreciation of the fact that the residual numbers of bacteria in a filtered water should receive attention as well as the percentage of bacterial removal. Taking everything into consideration, it would appear to your Committee to be advisable to adopt 48 hours as a standard period of cultivation under the conditions noted above. Before making a final recommendation there is requested a further expression of opinion on the part of the members of the Section of Bacteriology and Chemistry.

Relative to the records of the numbers of bacteria per cubic centimeter, there are many workers whose custom is very loose and unscientific. Your Committee disapproves of customs which indicate a fictitious accuracy in current methods, by the inexcusable use of significant figures in the units place where the numbers are very high.

Differentiation and Classification of Species of Bacteria.—This branch of bacteriology is of much importance in connection with water analysis, because reliable and readily available methods for the detection of water-borne disease germs cannot be established until this general subject has been placed upon a more scientific and substantial basis. It is true, of course, that progress for a time along this line must be largely a matter of pure science, and that interest in these developments is shared not only among water analysts, but all workers in applied bacteriology.

Your Committee has made every reasonable effort to secure a consensus of opinion as to how this subject now stands, with reference to the soundness or weakness of the various current methods and procedures. While the views of a number of prominent workers, especially those not directly connected with water analysis, have not yet come to hand, it is believed that the general status of affairs may be correctly outlined as follows :

It is now universally recognized that the first requisite toward successful work in this field is the use of culture media of uniform standard composition. With the view to the accomplishment of this end, the methods of preparation of media recommended by the Bacteriological Committee in their Report of 1897 are in general use. Taken as a whole, they seem to have given, and to still give, general satisfaction. It is true, however, that in several laboratories these recommendations are departed from with regard to the manipulations which apparently affect but little the question of uniformity. Practice, furthermore, varies somewhat in a number of laboratories, with reference to the use of meat infusion as compared with meat extract; in the preparation of milk for a culture medium; and in the reaction of various media for species work. Each of these points requires attention.

Concerning those tests and procedures to be employed in order to secure diagnostic data in species work, it is plain that the recommendations of 1897 have caused material advances over previous methods. It is certain, however, that the 1897 Report in this respect has thus far met less support and approval than in the case of the preparation of culture media. The report has evidently set at work a leavening process in several places, and an improved state of affairs will presumably result in time. Why it is that with test after test there is a disagreement as to value among experienced workers is a matter which is not now understood, and which suggests unappreciated differences in procedures.

Relative to the results of those tests which are considered to be of differential value, and to the method of recording them, opinion is widely at variance. Some believe that they should be confined to those of a positive and definite nature. Other workers consider that they cannot be made too detailed and exhaustive.

In brief terms it may be said that, with regard to the general subject of species differentiation, a material step in advance has been taken in consequence of the Report of the Bacteriological Committee of 1897. As a result of the added knowledge coming to various workers through the general use of the 1897 Report as a guide, the time has arrived when that Report can and should be revised. Concerning the new evidence which has been obtained since that Report was prepared, it has not yet reached your Committee in a form adequate to allow changes to be recommended at this time. In fact, there are many indications which go to show that the amount of directly comparable evidence from the various laboratories is much less than is generally realized, owing to the wide variety in the nature of the species work now going on in this country.

In the opinion of your Committee the real issue for discussion to-day on this topic is not the question of detailed points of improvement, but rather the best general procedure by which species work can be elevated to a higher plane of excellence. This matter has received considerable thought from the Committee, and it would appear that as a first requisite it will be necessary to secure the cooperation of the workers in other branches of bacteriology. It would also appear to be necessary to secure comparable data upon corresponding cultures of the same species from a considerable number of experienced workers. Further, it would be very desirable if data from the same species could be obtained at the same laboratory with culture media prepared by a number of other investigators.

Fermentation Tests and the Detection of B. coli communis and other Specific Forms.—While these methods come within the scope of general species methods for bacteria, it is considered that they are entitled to separate consideration. This is due to the fact that

this subject is studied by many water analysts who do not attempt general species determinations, and to the further fact that upon these topics opinion is more crystallized than upon the general subject of species methods.

Relative to fermentation tests, this topic was considered at length by the Bacteriological Committee in the Report of 1897. The present status with reference to those recommendations may be outlined as follows:

In the preparation of fermentation solutions, the use of meat infusion as compared with meat extract is still an open question. Both are used. Opinion seems unanimous, however, that in either case they should contain no muscle sugar. It is generally considered that a reaction of 1.5 per cent. acid is not perfectly satisfactory, and most workers employ solutions which are practically neutral to phenolphthalein. The amount of sugar is 1 per cent. as a rule, as recommended, although it appears that glucose is used by many to the exclusion of lactose and saccharose. This latter tendency would seem to be a step in the wrong direction, for many lines of work. Opinion is at variance concerning the effect of heat upon these sugars in the course of the preparation of the solutions. Cultivations are made almost invariably at 37 degrees C. for a period of three days, with records daily as to the percentage of gas in the closed arm. In other particulars there are some differences in general practice, but they apparently are of little consequence in affecting results such as would be obtained by strict adherence to the procedures of the 1897 Report.

While considerable increase to our knowledge of the fermentation-produced bacteria has occurred within the past three years, there is not at present sufficient evidence at hand to recommend an improved set of procedures.

With regard to the isolation of *B. coli communis*, there are evidently quite a number of procedures which are used with success. These procedures differ somewhat on account of the wide range in natural conditions under which tests are made for this form in various waters. Where *B. coli communis* forms a small percentage of the total bacteria, the custom appears to have come into general use of employing a preliminary incubation to eliminate ordinary water bacteria. It is thought that it will not be a laborious task during the coming year to draft a graded series of acceptable methods to cover the wide range of conditions met with in practice.

It is gratifying to note a general uniformity in the characteristics considered essential to the identification of *B. coli communis*, as follows:

1. Fermentation of dextrose with the production of carbonic acid equal approximately to 33 per cent. of the total gas formed.

2. Coagulation of milk.

3. Non-liquefaction of gelatine, with growth at the surface and in the form of beads along the line of inoculation in a gelatine tube-culture.

4. Formation of indol.

5. Conformity to the main morphological characteristics of this type as published.

With reference to those forms resembling *B. coli communis*, which ferment sugars with the production of carbonic acid varying widely from 33 per cent. of the total gas, it is now generally regarded that they should not be reported as *B. coli*. What their true relation is to this species, and what their sanitary significance is relative to the character of waters in which they are found, are questions which cannot be answered satisfactorily at present.

Very few, if any, experienced bacteriologists engaged in public health work make a practice of attempting to isolate the ty-

phoid bacillus or any specific forms other than *B. coli communis.* For obvious reasons it is inadvisable at this time to give this phase of water analysis any detailed consideration.

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*SUNSPOTS AND RAINFALL.**

AT the meeting of the Royal Society on November 22d, Sir Norman Lockyer and Dr. W. J. S. Lockyer presented a paper on 'Solar Changes of Temperature and Variations in Rainfall in the Region Surrounding the Indian Ocean.'

Sir Norman Lockyer, who made the communication, said the fact that the abnormal behavior of the widened lines in the spectra of sunspots since 1894 had been accompanied by irregularities in the rainfall of India, suggested the study and correlation of various series of facts that might be expected to throw light on the matter. Among the conclusions thus arrived at were: (1) A discussion of the chemical origin of lines most widened in sunspots at periods of *maxima* and *minima* indicated a considerable rise above the mean temperature of the sun around the years of sunspot *maximum* and a considerable fall around those of sunspot *minimum.* (2) From the facts of rainfall in India (during the southwest monsoon) and Mauritius between the years 1877 and 1886, as given by Blanford and Meldrum, the effects of these solar changes were seen to be felt in India at sunspot *maximum* and in Mauritius at sunspot *minimum,* the greater effect being in Mauritius. The pulse in Mauritius at sunspot *minimum* was also felt in India, giving rise generally to a secondary *maximum.* India, therefore, had two pulses of rainfall, one near the *maximum* and the other near the *minimum* of the sunspot period. (3) The dates of the beginning of these two pulses in the Indian and Mauritius rainfall were related to the sudden remarkable changes in the behavior of the widened lines. (4) All the famines recorded in the Famine Commission reports as having devastated India during the last half-century occurred in the intervals between these two pulses. (5) Investigation of the changes in (*a*) the widened lines (*b*) the rainfall of India, and (*c*) the rainfall of Mauritius during and after the last *maximum* in 1893 showed in all three important variations from those exhibited during and after the last *maximum* of 1883. The *minimum* of 1888–89 resembled the preceding *minimum* of 1878–79. (6) From 1849–1878 the lowest Niles recorded occurred between the same intervals. (7) Although the relations of these intervals to the droughts of Australia and of Cape Colony, and to the variations of rainfall in extra-tropical regions generally, had not been investigated, a general agreement had been made out between the intervals and the rainfall of Scotland, and both pulses had been traced in the rainfalls of Cordoba and the Cape of Good Hope. (8) The results of the inquiry having been placed before Mr. John Eliot, Meteorological Reporter to the Indian Government, he gave it as his opinion that they accorded closely with all the known facts of the large abnormal features of the temperature, pressure, and rainfall in India during the last twenty-five years, and that hence the inductions already arrived at would be of great service in forecasting future droughts in India.

When the image of a sunspot was thrown on the slit of a spectroscope, examination of the spectrum indicated that the blackness of the spot was due not only to general but also to selective absorption, and that the lines widened by the selective absorption varied from time to time. From many years' observations of these widened lines it appeared that at some periods they were distinctly traceable to known elements, while at others their origins had not been

* From the London *Times.*